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Using empirical data from streamflow gauges to quantify uncertainty

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In hydrological modelling, it is common practice to use statistical methods only to quantify uncertainty in the models. This is partly because statistical methods provide objective qualification of uncertainty by numerical implementation, and partly because such uncertainty estimates do not rely on information of the data source but only on the error assumptions of the data. Therefore they can be used even when there is limited or no empirical data. A corollary to this is perhaps the failure in many studies to make full use of the information contained within empirical data to inform uncertainty analysis. Here we present a method to examine gauge uncertainty using gaugings and rating curves from streamflow gauges in the Namoi River catchment, Australia. The gauges show a large scatter in gaugings especially at low discharge and multiple rating curves were used to reflect continuing shifts in the stage-discharge relationship over time. These, along with other problems would normally deter empirical analysis in favour of statistical estimates. However, we show how a simple analysis of the deviations in gaugings from the rating curves can provide important information on the reliability of streamflow records and indeed provide guidance for error models where statistical uncertainty methods are still being used to determine total uncertainty (including uncertainty in streamflow). We then describe the use of the bootstrap to determine prediction limits for each rating curve given problems in violating the assumptions of standard rating curve uncertainty methodologies. The bootstrap prediction limits are used to define error bounds for daily flows in the observed record. Empirically-based quantification of the uncertainty in observed streamflow records has several important implications for model uncertainty, particularly since flow data is often used in models for multiple purposes, including input data, calibration of parameters and verification of model performance. Empirical analysis of data can also provide additional useful information on system behaviour and response that can be used to inform other uncertainty analyses such as model structural uncertainty. This additional information is something which statistical methods for total uncertainty cannot provide.